a product is obtained consisting largely of the first chlorobromide, $SiCl_3Br$. It is comparatively easy to separate, by fractional distillation, this compound, which boils at 80°, from the remaining tetrachloride, and the $SiCl_3Br$ thus obtained in a fairly pure state serves for the preparation of the second and third chlorobromides by passing its vapour, instead of the tetrachloride, together with hydrobromic acid through the hot porcelain tube. The second chlorobromide, $SiCl_2Br_2$, has been said to boil about 100°. M. Besson finds that his carefully purified specimen boils at 103°–105°. It was found impossible to separate the third compound, $SiClBr_3$, from this second one by fractional distillation but by taking advantage of the fact that the second chlorobromide cannot be solidified at $-60°$, while the third compound solidifies at $-39°$, and afterwards distilling the solid obtained, the third compound, $SiClBr_3$, has been isolated as a liquid boiling at 126°–128°. This substance exhibits the property of superfusion in a very high degree; it may be cooled as low as $-50°$ without solidification ensuing, provided the liquid be maintained perfectly still. On agitation to even the slightest extent, however, it suddenly solidifies, the thermometer rising instantly to $-39°$. All three chlorobromides combine directly with gaseous ammonia to form additive compounds, white amorphous solid bodies decomposed by water. In case of the first chlorobromide, $SiCl_3Br$, a similar compound has been obtained under pressure in a Cailletet tube with phosphoretted hydrogen, PH_3. The combination occurs at 0° under a pressure of 25 atmospheres, or at $-22°$ under 17 atmospheres, all the liquid being then transformed into a white solid, which persists when the pressure is removed, but which is again dissociated upon slightly warming the tube.

THE additions to the Zoological Society's Gardens during the past week include a Lesser Ourang-Outang (*Simia morio* ♂) from Sarawak, Borneo, presented by Commander Ernest Rason, R.N.; two Suricates (*Suricata tetradactyla*) from South Africa, presented by Mr. J. W. Munt; two Azara's Opossums (*Didelphys azaræ* ♂ ♀) from La Plata, presented by Mr. Edward C. Hawe; a Lion (*Felis leo* ♀), bred in Holland; a Nylghaie (*Boselaphus tragocamelus* ♂), bred in France, purchased; a Grey Parrot (*Psittacus erithacus*) from West Africa, deposited.

THE PRESENT METHODS OF TEACHING CHEMISTRY.[1]

IN their second Report, which was presented at the Newcastle-on Tyne meeting, the Committee gave an account in some detail of the general lines which, in their opinion, an elementary course of instruction in physical science might most profitably follow. During the past year the Committee have been principally engaged in collecting and comparing the regulations, with respect to chemistry, which are issued by the more important of the examining bodies in the kingdom, in order to discover how far their requirements are in harmony with such a course of instruction as that suggested by the Committee. Since the information which has been collected is of general interest, the greater part of it is here printed. It consists of a brief outline of the noteworthy features in the regulations of the various Examination Boards, and, wherever it appeared necessary, of recent examination papers. The examinations about which information is now given are as follows:—

Oxford and Cambridge Schools Examination Board.
University of Cambridge Local Examinations.
University of Edinburgh Local Examinations.
University of Glasgow Local Examinations.
University of London Matriculation.
University of Durham Certificate for Proficiency in General Education.
Victoria University Preliminary Examination.
College of Preceptors—Professional Preliminary Examination.
Science and Art Department Examination in Chemistry.
Intermediate Education Board for Ireland.
Civil Service of India.
India Forest Service.
Royal Military Academy, Woolwich.
Cadetships, Royal Military College, Sandhurst.
Engineer Students, H.M. Dockyards.

With respect to the regulations which relate to these examinations, the Committee consider it desirable to direct especial attention to the following points.

It is of great importance that natural science should be sufficently represented on the Board which issues the regulations and is responsible for the proper conduct of the examination. It is remarkable that, although chemistry is an important subject in the Oxford and Cambridge Schools Examination, no representative of this science is appointed by either University to act on the Examination Board, whilst Oxford does not appoint a representative of any one branch of natural science.

The Committee note with satisfaction that in these examinations, most of which are held to test proficiency in general education, chemistry is generally included, in addition to one or more branches of experimental physics, and that in many cases the examination is in part a practical one. An important exception to this statement is found in the case of the University of Durham, which, although it grants a certificate of proficiency in general education, does not include among the subjects of this examination either chemistry or any branch of experimental science. Science is represented only by elementary mechanics, and even this is an optional and not a compulsory subject.

As regards the status occupied by chemistry and experimental physics in public examinations, the position of these subjects is still frequently lower than that of the other principal subjects of examination, and much yet remains to be done to secure the adequate recognition of the educational value of natural science. Attention may here be drawn to the position assigned to physical science by the Intermediate Education Board for Ireland, upon whom devolves the examination of most of the Irish public schools. According to the regulations at present enforced by this Board, natural philosophy and chemistry appear as optional subjects, each having a relative value represented by 500 marks, the value of Greek and Latin being assessed at 1200 marks each. It is to be hoped that the Commissioners may, before long, see their way to introduce elementary physical science as a compulsory subject of these examinations, and to increase the marks assigned to it beyond the present number of 500, which is less than one-half of that awarded to Greek or Latin (1200).

Another very anomalous case is that of one of the Civil Service examinations, viz. the examination for engineer students in H.M. Dockyards. In this examination, "very elementary physics and chemistry" are included as a single subject, to which is allotted 100 marks out of a total number of 1950! In the profession for which this is an entrance examination, applicable to boys who are about to leave a public school, not only is the possession of a scientific habit of mind of the highest moment, but a considerable knowledge of physics and chemistry is indispensable.

The Committee are strongly of opinion that some attempt should be made to remedy a conspicuous deficiency in nearly all existing examinational regulations. It is virtually impossible to ascertain, in the course of a single short examination, especially when the number of candidates is large, whether sufficient time has been devoted to the study of the elements of physical science to make it of permanent advantage to the student; neither is it possible to determine whether the character of the instruction has been in every respect satisfactory. Periodical inspection of the teaching by properly qualified inspectors, such as is now practised to some extent by more than one Government department, would seem to constitute the best method of dealing with this defect, the reports of the inspectors, as well as the students' own record of work testified to by the teacher, being taken into account in awarding prizes, certificates, and grants, in addition to the results of an examination.

With respect to the schedules and examination papers, typical specimens of which are here printed, it will be seen that for the most part they do not aim at an educational training of the kind suggested in the Committee's last report. Although nearly all the examinations included are intended to maintain a high standard in general education, yet, as a rule, the schedule of work proposed and the questions set in the papers are more suitable for those who wish to make a special and detailed study of chemistry as a science. Insufficient attention is paid to problems, like those suggested in the Committee's last report, designed to develop the power of accurate observation and correct inference; few of the questions asked are adapted to test the mental power of students, which should have been strengthened and trained by the experimental study of physics and chemistry. The great majority of the questions asked involve an enumeration of the properties and modes of preparation of different chemical substances; but this by itself is a wholly unsatisfactory method of ascertaining whether a student has derived benefit from experimental work. The mere writing out by the student of methods of preparation of individual substances is no proof that he has learned chemistry. The Committee are of opinion that it is not advisable to ask young students to give purely formal definitions of chemical terms. A glance at the examination questions appended will show that definitions of such terms as *atomic weight*, *molecular weight*, *water of crystallization*, *acid*, *base*, *salt*, are often demanded. Such questions encourage many students to learn by rote certain forms of words without attempting to grasp the facts and generalizations which those words summarize. Moreover, as many, if not most, of the terms used in chemistry cannot be defined, the demand for definitions of these terms by examiners leads to a pernicious and unscientific way both of teaching and learning, by which an apparent accuracy in the use of phrases is substituted for a real acquaintance with facts and principles. Again, too much attention is often devoted to calculations which, while they furnish useful exercises, do not necessitate any special scientific knowledge. Another noteworthy feature of these examination schedules and papers is the very general exclusion of any reference to organic substances. There appears to be no reason, even in elementary examinations, why the questions should be exclusively confined to inorganic materials. Moreover, elementary organic chemistry can be made the basis of excellent training in scientific method, especially if the teaching does not follow the formal order or aim at the completeness which are usual in text-books, most of which are written for those who are studying chemistry as a special subject, and not chiefly for the sake of the educational benefit which may be derived from it. In general elementary teaching at any rate it is unnecessary even to make the conventional distinction between inorganic and organic chemistry.

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[1] Third Report of the B.A. Committee, consisting of Prof. H. E. Armstrong, Prof. W. R. Dunstan (Secretary), Dr. J. H. Gladstone, Mr. A. G. Vernon Harcourt, Prof. H. McLeod, Prof. Meldola, Mr. Pattison Muir, Sir Henry E. Roscoe, Dr. W. J. Russell (Chairman), Mr. W. A. Shenstone, Prof. Smithells, and Mr. Stallard, appointed for the purpose of inquiring into and reporting upon the Present Methods of Teaching Chemistry. (Drawn up by Prof. Dunstan.) To which is appended a Paper, by Prof. Armstrong, on "Exercises in Elementary Experimental Science."

The foregoing remarks apply not only to school examinations, but also to the various Civil Service examinations, where it is of the highest importance that candidates should have received a sound scientific training. Most of those selected will afterwards fill positions in which the scientific method of dealing with the various problems which will constantly be presented for solution cannot fail to be of the highest value.

It may perhaps be thought that a great deal of what has been said in criticism of the present examinational demands in physical science, might more properly have been urged against the teaching. But since the first report of this Committee was issued, in which attention was drawn to the defective character of much of the elementary teaching, it has been repeatedly represented by teachers in schools of every grade that the character of their instruction is necessarily governed by the requirements of examiners, and that if modifications were made by Examining Boards in the present regulations it would be possible at once to make the corresponding changes in the methods of teaching.

The obvious conclusion is that the necessary reforms can only be brought about by the active co-operation of examiners and teachers.

[Here follow, in the Report, a selection of examination papers.]

Appendix.

Exercises illustrative of an Elementary Course of Instruction in Experimental Science. By Prof. Armstrong.

The scheme put forward in the report presented last year by the Committee sufficed to indicate the kind of instruction likely to inculcate habits of observing correctly, of reasoning from observation, and of setting new questions and obtaining answers thereto by experiment and observation: habits which it is now generally admitted are of great consequence in the struggle for existence, and which cannot be acquired except through training in the methods of experimental science. Nevertheless, it has been felt that detailed directions how to proceed were necessary for the use of the less experienced teachers, and that even those who fully sympathize with the proposals already made would welcome the more complete display of the system. I have therefore obtained the permission of the Committee to append the following suggestions to their report, in amplification of certain parts of the scheme already published.

It is obviously impossible to sketch more than a small portion of a complete programme of instruction; the portion now offered is that appropriate to the earliest stage in which quantitative studies can be engaged in: its study can be commenced by children of fair intelligence when nine or ten years old. It is an essential feature of the scheme that it has reference to common things, the object being to lead children to engage in the rational study of the objects which are daily brought under their notice.

Time to be devoted to Experimental Studies and Mode of Teaching.—Frequently during the past year the question has been put to me, "How much time is to be devoted to such science teaching?" and complaint has been made of the difficulty of dealing with large classes of children, of keeping them employed, and of providing the requisite space and appliances.

The question as to time will ever continue to be put until the fundamental fallacy which hitherto has retarded the progress of experimental teaching in schools is discarded, viz. that sufficient training in a scientific subject can be imparted in the course of a term or two. This undoubtedly is the view entertained in the majority of schools—girls' schools in particular. It is well known, for example, that of the many hundred students who each year present themselves at the London University Matriculation Examination, the vast majority have had but a *few months' coaching* in chemistry, mechanics, or physics, although they have had lessons in arithmetic and like subjects during the *whole period* of their school career. It was long a superstition that to pass in chemistry all that was necessary was to have read some one of the small text-books, and a very large proportion of matriculants have doubtless had only such preparation. The fact is that our schools hitherto have been all but entirely in the hands of those who have had a purely classical or mathematical training, and who have gained their knowledge by reading; teachers thus trained cannot realize that the useful effect of science teaching is only attained when the instruction is carried out on entirely different lines; they cannot realize that *accurate experimenting* is the essential feature in the system; that knowledge gained by mere reading is and can be of little use, as in acquiring it the mental faculties which it is desired to exercise never become trained. It must be recognized by all who have charge of schools that, in order to secure the due development of those faculties which science teaching alone can affect, the instruction must be imparted *from the very beginning and during the entire period of the school career.*

If this be done, many of the difficulties hitherto encountered may disappear. Probably it will be found advantageous, at least in the earlier stages, rather than disadvantageous, to devote but a short time during any one lesson to actual experimental work. There is no doubt that far too much is usually attempted; that too many facts are brought under the student's notice in the course of the lesson, the result being a blurred mental picture destitute of sharp outlines. After considerable experience I am satisfied that it is difficult to proceed too gradually—it may almost be said too slowly.

The following two sets of instructions are given by way of illustration; it is not pretended that they are complete, nor is it suggested that the exercises should be worked through exactly in the order in which they are stated, or completed by all pupils; the teacher must determine which are suitable for the particular set under instruction.

Studies of Water and Common Liquids.

1. Make every effort to elicit from the pupils by question and answer all that *they* have noticed with regard to water. Induce them to take advantage of any opportunities the neighbourhood affords of observing water and its effects. Let them ascertain the area covered by the school-house roof and the amount of water which falls on it when it rains; institute systematic observations of rainfall, and embody the data in arithmetical exercises. Call attention to the different yearly rainfall of different parts of the country, and point out the influence of hills

and mountains: let outline maps be coloured, so as to indicate the different rainfall of different districts.

2. Call attention to the geographical distribution of water, &c.; also to the work which it does in Nature (cf. Geikie's "Physical Geography," Huxley's "Physiography," &c.), illustrating this part of the subject, especially at an inland school, by lantern photographic slides of ships, sea-coasts, Niagara Falls, &c.

3. Call attention to the disappearance of water, *i.e.* the drying up of rain, the drying of clothes, &c., and lead the pupils to notice that this takes place most quickly in hot weather and in warm places; then let them pour water into a clock glass placed either over a saucepan in which water is boiled by a gas-burner (or petroleum or spirit-lamp, if gas be not available), or in a small gas cooking-stove; they will see that the water evaporates, leaving a certain amount of *residue.* [At this stage experiment on the extent to which water evaporates out of doors and indoors under different conditions and at different times of the year by exposing water in weighed glass (crystallizing) dishes about 4 inches in diameter, and weighing at intervals. Also call attention to the fact that in certain states of the weather things become damp, and that moisture is sometimes deposited on the windows in cold weather; then let the condensation be noted of a liquid indistinguishable from water, which occurs, for instance, when a closed flask filled with water and ice is exposed in a room. Let some seaweed inclosed in a muslin bag be hung up out of doors where it cannot be wetted by rain, and have it weighed daily. At the same time have the temperature, direction of the wind, and character of the weather noted. Later on have the dry and wet bulb thermometer read daily. Have the changes in weight of the seaweed and the dry and wet bulb thermometer readings represented by curves. Lead the pupils to contrast and discuss the results.] The experiment should then be repeated with a known quantity of water and a weighed glass dish, so as to determine the amount of residue; the character of the residue should be noticed. Discuss the origin of the water, and point out whence the residual matter *may* have come. Next, if a well water was taken, let a local river or pond water be examined in a similar way, then rain water, and, if possible, sea water.

4. Let an ordinary 2-ounce narrow-mouth stoppered bottle, having a nick filed down the stopper, be filled with each of the waters and weighed, and let the operation be repeated several times with each water, so that the *experimental error* may be ascertained; it will be found that the different waters, sea-water excepted, have practically the same *density.* At this stage arithmetical exercises relating to the weight of known bulks, and *vice versâ*, of water, the quantities of dissolved solids present in given bulks of various waters, &c., may advantageously be set; these should be solved practically by actual measurement in as many cases as possible.

5. Next ask, "But what becomes of the water when driven off by heat?" If it have not been noticed that water collects (condenses) on some object near at hand, let a cold object be held over boiling water, then let water be boiled in a glass flask connected with a glass condenser. Afterwards have water distilled in larger quantity from a tin (2-gallon) can. The density of the distilled water should then be determined, and its behaviour on evaporation. Data would thus be accumulated, rendering it possible to explain the drying up of water under ordinary conditions, the origin of rain, the differences between waters from various sources, and the method of separating water from the associated foreign matters will have been brought home to the minds of the pupils.

6. As the water is heated to boiling in the flask, if attention be paid to all that occurs, it will probably be noticed that bubbles separate from the water, rising up through it and escaping at the surface; frequently the bubbles adhere for a time to the flask. Let the experiment be repeated in such a way that the something which escapes from the water can be collected and measured. For example, a 2-gallon tin can having been filled with water, insert into the neck a rubber cork through which a bent *delivery tube* is passed; place the can over a burner, introduce the upturned end of the delivery tube into a basin of water, and insert a small jar over it. Heat to boiling. An air-like substance will gradually be driven off, but it will be noticed that after the water has been boiling for some time it ceases to give off gas; let the amount of gas collected be measured, and have the experiment repeated several times. As the gas does not continue to come off on boiling the water, it would seem that it is not a part of the water—there is so little of it, but merely something dissolved in the water; it is like air, and the water had been in contact with air—may it not be air? Let the boiled water be poured out into a galvanized iron pan, and after it has been exposed to the air for several hours let it be again boiled. The water which previously no longer gave off gas, will now yield probably as much as before. It will thus be discovered that water dissolves air as well as the solid matters with which it comes into contact, and the presence of air in water will be recognized. This knowledge will be of value later on when the existence of animals and plants under water comes to be considered.

7. Attention having thus been directed to the solvent action of water, let special experiments be made on its solvent action, using salt, sugar, suet, washing soda, alum, tea and coffee, field or garden soil, clay, chalk or limestone, gypsum, &c.; known quantities of the filtered solutions should be evaporated to dryness, and the residues dried (conveniently in a small gas cooking-oven) and weighed. Opportunity will be afforded to call attention to the separation of some of the substances from solution in definite shapes, *i.e.* crystals; show these under the microscope as well as home-made cardboard models of some of them. Let larger crystals of alum be grown, and call attention to sugar crystals. Natural crystals of calcite, gypsum, pyrites, quartz, fluorspar, &c., would be appropriately shown at this stage. The question may then be put, Does the water which passes through the body dissolve anything? By evaporating urine and determining the amount of dried residue it would be found that a good deal of matter passes away from the body in solution.

8. Having directed attention to the different behaviour of different waters with soap, let determinations be made of the amount of alcoholic soap solution required to produce a lather in distilled and other waters. Directions for performing the soap test are easily obtained from a book on water analysis, and the operation is one of extreme simplicity.

9. Other liquids should now be compared with water, such as methylated spirit, turpentine, petroleum, salad oil, vinegar, and perhaps the common acids—muriatic, nitric, and sulphuric—also. The noticeable differences between these and water—appearance, odour, taste in dilute solution—having been registered, their relative densities should be determined; also their behaviour towards water and towards each other, their behaviour when heated on the water-bath in comparison with that of water, their behaviour when burnt, their behaviour when boiled together with water in a flask attached to a condenser, and their solvent action in comparison with that of water should be ascertained.

10. Having given an account of the origin, &c., of the various liquids examined, and having alluded to the presence of alcohol in beer and wine, demonstrate the separation of alcohol from beer by distillation; then describe the production of alcohol by fermentation and carry out the experiment, first with sugar and yeast, then with malt; explain that yeast is an *organism*, and show it under the microscope and lantern photographs of it. Make several mixtures of alcohol and water, and let the relative density of each be determined; then exhibit a table of relative density of spirit solutions of various strengths. Let a measured amount of beer be distilled, have the distillate made up with distilled water to the bulk of the beer taken, and let its density be determined; reference being then made to the table of relative densities, the strength of the alcoholic distillate would be ascertained, and thus the amount of alcohol in beer would be determined.

11. The behaviour of water when heated may now be further studied: attention having been called to the thermometer as an instrument which enables us to judge how hot or cold it is, water should be heated and the gradual rise of the mercury column noted, and the steady position which it assumes when the water boils. In the same way boiling water should be allowed to cool and the fall of the mercury column noted; further cooling should then be effected by means of ice, so that opportunity might be given for the stationary position to be observed which the column eventually takes up and maintains so long as unmelted ice is present. Having specially directed attention to these "fixed points," describe the construction of the thermometer. Next let a quantity of water be distilled from a flask or can having a thermometer in its neck, and let the steady position of the mercury throughout the distillation be observed. Also let water be frozen by means of a mixture of ice and salt; the "temperature" of the freezing mixture having been ascertained, the thermo-

meter bulb should be inserted into the water which is being frozen (in a test tube), so that the ice may form around its bulb: the temperature should be noted during freezing and also during the subsequent melting of the ice. Do this out of contact with the refrigerating mixture.

12. Let the relative density of ice be determined, *i.e.* after showing that although "lighter" than water ice is "heavier," than turps, let a cylinder partly filled with turpentine be counterpoised, and after the temperature has been lowered by immersing the cylinder in ice water, note the position of the turps, then introduce a few pieces of dried ice, note the rise of the turpentine—thereby determining the volume of the ice—and subsequently weigh in order to ascertain the weight of ice introduced. Have the result thus obtained checked by subsequent observation of the bulk of water which results when the ice melts. The expansion of water on freezing having thus been observed, the bursting of pipes in winter may be explained; and attention may also be directed to the destructive effects on rocks produced by the freezing of water; the extent to which ice floats may be discussed, and arithmetical problems may be set which will lead the pupils to realize the extent to which the volume changes when water changes its state.

13. Let the relative density of water and the other liquids be determined at 0° C. and at a higher temperature—that at 0° by weighing, and that at the higher temperature by observing the expansion of the liquids in bulbs with graduated stems of known capacity; let curves be constructed showing the relation between temperature and volume.

14. Let spirit, turpentine, petroleum, and vinegar be distilled; the temperature during distillation being observed, the gradual rise especially in the case of spirits and petroleum will be noted. Fractionally distil several times some quantity of spirit and of petroleum; let the relative density of each separate fraction be determined, and let the water separated from the spirit be characterized by freezing it and determining the melting-point of the ice and the boiling-point of the liquid which results when the ice melts.

15. Having directed attention to the fact that heat is "used up" in melting ice and boiling water, let determinations be made of the amounts, following Worthington's "Practical Physics," for example.

Studies of Chalk and other Common Solids.

1. Call attention to the use made of lime in building and its production from chalk or limestone; slake a lump of lime; exhibit specimens and pictures of chalk cliffs or quarries and lime-kilns—if not to be seen in the district. Point out on a geological map those parts of the country in which chalk occurs, and those where limestone is met with. Explain how chalk is supposed to have been formed, and show pictures of the forms which are present in it, and, if possible, microscopic slides. Explain that whitening, which is purchasable everywhere, is but lævigated chalk; describe its preparation, and let chalk and sand be separated by lævigation.

2. Let the conversion of chalk into lime be studied quantitatively. For this purpose three to five grams of dried whitening should be weighed out in a small platinum dish and heated to full redness in the *covered* dish during an hour over a Fletcher Argand Bunsen burner: the dish is then removed from the burner, and after about ten minutes, when cold, is weighed; it is then again heated, say for half an hour, &c.; usually there is no further loss. Several experiments should be made in this way, so that it may be noted that practically the same percentage of loss is incurred and the same amount of lime obtained in each case; and similar experiments should be made with chalks from different localities (Note A).

3. At the conclusion of each experiment, the residue should be carefully moistened with distilled water and the effect noticed; usually the lime slakes, becoming hot—some limes, however, slake very slowly, and the heating is imperceptible. The excess of water should then be driven off by heating in a water-oven until the weight no longer diminishes.

4. In comparing the solvent action of the various liquids previously studied, it will probably have been noticed that chalk is dissolved by acids—for example, vinegar or muriatic acid—with effervescence; such an acid may therefore be used, if necessary, in cleaning out the dish at the conclusion of the experiment if any of the solid adhere to it. Then, having made it clear that the effervescence is due to the escape of an air-like substance or gas, which is conveniently termed *chalk-gas*, let the amount of gas which is given off when the chalk is dissolved in acid be determined. For this purpose, the simple apparatus shown in Fig. 1 may conveniently be used. From 1·5 to 2 grams of the chalk is weighed out on a small square of tissue paper, which is then folded up at the sides and dropped into the bottle A, from which the tube B has been removed; a little water is then added (about 5 cubic centimetres), and the chalk is shaken out of the paper; about 5 cubic centimetres of nitric acid is now poured into the tube B, which is then carefully replaced in the bottle A. The cork having been inserted, connection is established by means of the flexible tube C with the bottle D. The side tube E having been so adjusted that the end *e* is on a level with the water in the bottle D, the measuring cylinder H is so placed that any water which runs from *e* may be collected in it, and the bottle A is then carefully tilted so that the acid may gradually run out of the tube B into A; gas is at once given off and expels water from D. As the water sinks in D, the side tube E is lowered so that its orifice remains about on a level with the water in D. The water is then measured. Several experiments should be made, and the results should be compared by calculating the volume of gas which would have been obtained, supposing, say, 100 grams of the chalk had been dissolved.

5. In this way it is ascertained that *chalk-stuff* is *characterized* by (1) yielding between 56 and 57 per cent. of lime, which increases by about 33 per cent. when slaked; and (2) by yielding about 22,000 cubic centimetres of chalk-gas per 100 grams when dissolved in acid.

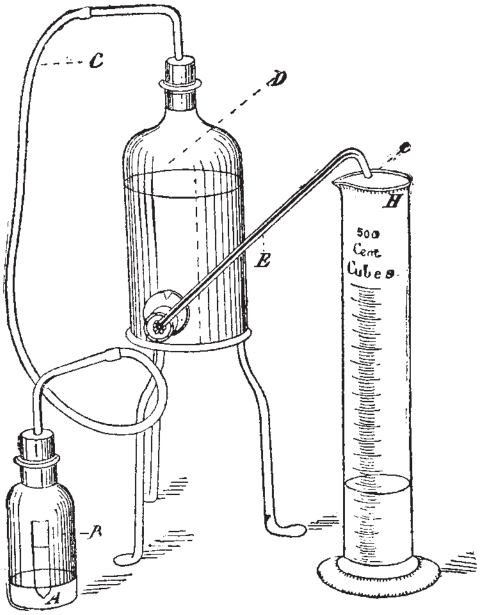

Fig. 1.

6. Comparing lime with chalk, it is found that if the chalk be thoroughly burnt no gas is evolved on dissolving the recently slaked lime in acid; this result serves at least to suggest that the gas which is given off when chalk is dissolved in acid is perhaps expelled during the conversion of chalk into lime. The loss in weight which occurs is therefore determined, and when it is ascertained that it is very nearly the same as when chalk is burnt, no room is left for doubt that the same substance is dispelled by heating and by dissolving the chalk in acid. The experiment is very easily carried out in a small bottle or conical flask provided with a tube to contain acid, and closed by a cork through which pass a narrow tube bent at a right angle and a small drying tube full of cotton-wool. The chalk is weighed out on thin paper and dropped into the flask, a little water is poured on to it, and the acid tube is then introduced, after which the cork is inserted. The bent tube is closed by a small stopper. On tilting the flask, acid escapes and attacks the chalk; the spray is prevented from escaping by the cotton-wool. When the action is at an end, air is sucked in through the narrow bent tube to displace the chalk-gas, and finally the

loss in weight is determined. Such an apparatus gives admirable results.

7. Marble may then be examined in a similar way; as it is found to behave both on heating and when dissolved in acid much as chalk does, it may be presumed to consist of chalk-stuff. Next, limestones should be taken; the result obtained with them may be lower owing to their containing clay, &c.; but this is to a large extent rendered evident by insoluble matter left on treating with acid. Let the percentage of chalk-stuff in the limestones be calculated from the results which they afford, assuming the results obtained with chalk to be practically those afforded by pure chalk-stuff. Lastly, direct attention to the occurrence of crystals (calcite) in limestone rocks, to stalactites, &c.; show specimens, and have them examined: the results will show that they also consist of chalk-stuff.

8. Having pointed out that chalk consists of shells, &c., of sea-animals, coral and shells of various kinds—oyster, cockle, limpet—should be given for examination; all these will be found to give results from which it may be inferred that for the most part they consist of chalk-stuff. Egg-shell and lobster or crab-shell in like manner will be found to yield lime when burnt, and to behave much as chalk does towards acid, but the presence of a certain amount of "animal" matter will be evidenced by the blackening on heating, and the insolubility of a certain proportion in acid.

9. Ordinary bone, gypsum, clay, and rocks other than chalk or limestone rocks are next given for study, in order that it may be discovered that the behaviour of chalk-stuff is peculiar and characteristic, and that there are many varieties of natural solids. Rough estimates of the amount of chalk in soil may be made by determining the amount of chalk-gas evolved on treating the soil with acid.

10. In a hard-water district the residue from the water will probably look more or less like chalk; its behaviour when treated with acid and when strongly heated should therefore be determined, and local boiler or kettle scale should then be studied as chalk was previously.

11. In this manner a large number of data will be accumulated which render it possible to discuss the origin of chalk; to explain the presence of chalk-stuff in water; and its withdrawal from water by animals; &c.

The study of chalk in the manner indicated would make it possible for the student (1) to comprehend the principle of the method followed by chemists in characterizing substances whereby they are led to discover distinct forms or species; (2) to realize not only that there are *compounds*, but also that such substances have a fixed composition; and (3) the entire difference in properties between a compound and its constituents would have been brought out most clearly by comparison of chalk-stuff with its constituents—lime and chalk-gas. The chalk studies, in fact, should serve to incite the student's curiosity, and should lead to further inquiries being undertaken as to the composition of other substances and the characters of their constituents, and as to the nature of other changes; and with regard to the method of undertaking inquiries into the composition of other substances, the important results obtained in the case of chalk by studying the *changes* which it undergoes would serve to illustrate the importance of studying change as a means of determining composition.

It cannot be denied that only well-informed, thoughtfu teachers could give useful instruction in accordance with the foregoing schemes; but this is scarcely an objection. The amount of special training required to carry out the experimental portion would not, however, be great; and there is no reason why such instruction should not be given in schools where there is no special science teacher engaged—although the services of such a teacher would undoubtedly be necessary if instruction in accordance with the more complete scheme embodied in the report presented last year by the Committee were carried out in its entirety.

The suggestion that probably it will be found advantageous, at least in the earlier stages, rather than disadvantageous, to devote but a short time during any one lesson to actual experimental work would be realized in practice if the experimental science lesson were associated with the measurement or practical arithmetic and drawing lessons; and it is difficult to imagine that this is not possible. Suppose a set of twenty-four pupils to be at the disposal of a teacher during an entire morning or afternoon in a room of sufficient size, properly appointed, and that they are set to work to carry out the experiments with chalk, described above. Several—say six—might be told off to weigh out in platinum dishes the necessary quantities of whitening, and having then placed the dishes on Fletcher burners or in a muffle, they would return to their places; at the end of an hour they would remove the dishes, and, after leaving them during ten minutes to cool, would weigh them. To determine whether any change took place on further heating, they would re-heat the dishes during, say, half an hour, at the expiration of which time they would, as soon as the dishes were cool, weigh them again. As soon as the first set of six had weighed out the chalk, a second set of six might be set to work in a precisely similar way if the necessary apparatus were available, or if not at some other exercise involving the use of the balance.

The nature of the experiments which each set were engaged in performing should be made known to the whole class, and all the data should be written up on a blackboard. Each pupil should write out an account of the experiments and of the results; opportunity would thus be given to compare the results of the six or twelve separate experiments. At the next lesson the two remaining sets of the class would carry out the same experiments. Each pupil would thus have the advantage of performing one or other of the experiments, and of knowing what results had been obtained by a number of fellow-students. If necessary, two pupils might be set to perform one experiment, care being taken that they took equal parts in it; and thus the whole class of twenty-four might complete the experiment or experiments in a lesson.

Those of the class who at any time were not actually engaged in carrying out the experiment might be occupied in other ways, *e.g.* in measuring distances, in drawing figures of stated dimensions, &c., in determining areas, in determining relative densities, in working out arithmetical problems, or in writing out notes and answers to questions. It would not be difficult as the class progressed to devise an infinite number of problems and exercises, the data for which were derived from experiments performed by the class.

If only one such lesson were given per week, a single teacher and an assistant might deal with 240 pupils, or with half that number if each class had two lessons per week—a much better course; and, working on a similar plan, much useful work might be done even in the course of two hours.

With regard to the appointments for such work, the schoolroom should be provided with simple working benches in addition to the ordinary desks and forms. A narrow table might be placed, preferably across one end of the room, on a raised platform, at which the teacher could sit and on which the balances could be placed; the teacher would then be able to supervise the weighing, and secure that due care were taken of the balances. A narrow bench (of deal, into which paraffin had been "ironed," so as to waterproof it) might be fixed against and along the wall at either side of the room. This should be fitted with simple cupboards and drawers for apparatus, and with gas taps if possible; and at a suitable distance from the wall and above the table there should be a bar carried by brackets affixed to the wall, from which various apparatus, small scales, &c., could be suspended. A simple draught arrangement should and might easily be fitted at each working place, so that no unpleasant or noxious fumes need escape into the room. At the other end of the room it would be desirable to have a demonstration table, and behind this, against the wall, a draft closet at one end of a bench at the other end of which was a capacious sink. It would be well also to have a sink within the closet, which could be made use of, for instance, in washing out a sulpuretted hydrogen apparatus. A muffle furnace at the side of the ordinary stove would be a most valuable adjunct.

The cost of carrying out experiments such as have been suggested remains to be considered.

The chief item is undoubtedly the balance. Useful work may be done at a very early stage of the measurement lessons with scales costing five or six shillings, as suggested by Prof. Worthington, but their use for quantitative chemical work, such as is comprehended in the foregoing scheme is entirely to be deprecated. The acquisition of the habit of weighing carefully and exactly is in itself a discipline of the utmost value, to which every boy and girl should be subjected. It is all-important, therefore, that a fairly good balance should be used, and that the utmost care in its use should be enjoined. When not in use the balance should be covered over with a cardboard box. Becker's No. 51 (Fig. 2) and No. 67 balances, to be had from Townson and Mercer, the English agents, are to be strongly recommended, the former being probably the more suitable, as the pans are carried by "bowed" wires, giving more room for manipulation, when, as in determining relative densities by the hydrostatic method, a bridge to carry a glassful of water is placed across the scale-pan. No. 51 costs £1 17*s.* 6*d.*; No. 67, £2 1*s.* A suitable set of weights (No. 31), from 500 grams downwards to centigrams, costs 18*s.* 4*d.* Even if six balances were provided—and such a number would suffice for a large class—the cost would be but £18.

A convenient size of platinum dish to use is one about ¾ inch deep and 2 inches wide, weighing, with a light cover, about 20 grams. At a normal price of platinum, such a dish would cost about 25*s.*, so that a considerable number might be provided for an outlay of £10. Such dishes not only last a long time when properly used, but are of value when damaged (Note A).

A water oven for drying would cost about £1; one of Fletcher's small air ovens for drying costs 17*s.* 6*d.*

Fletcher's Argand Bunsen burners, with tripod, are to be recommended as superior to the ordinary burners for school work. The smaller size costs 2*s.*; the larger, 3*s.* Suitable black rubber tubing for use with these burners, ⅜ inch in diameter, costs about 9*d.* per foot. A pair of iron crucible tongs costs 1*s.*

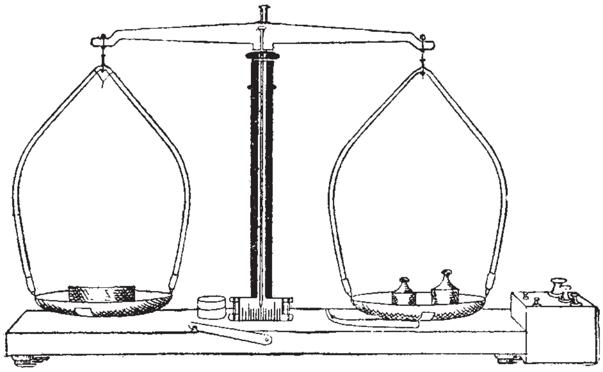
FIG. 2.

The apparatus for measuring the gas evolved on dissolving chalk in acid would cost about 7*s.*, including a 500 cubic centimetre measuring cylinder.

Glass basins about 3 inches in diameter cost 4*d.* each; clock glasses, 6 inches in diameter, 5*s.* per dozen.

50 c.c. burettes cost 3*s.* 6*d.* each.

It is unnecessary to refer to the cost of the few remaining articles required for the suggested experiments, as they are well known. An expenditure of £50 would certainly cover the cost of apparatus required by a class of, say, twenty-four, and which would suffice for the use of several such classes.

NOTE A.—The unfortunate rise in the price of platinum, which makes the purchase of any number of platinum vessels for school use out of the question, has led me to make a number of experiments in the hope of substituting silver; but, as was to be expected, this has proved to be impossible. I find, however, that porcelain may be used, provided that the heating be effected in a muffle furnace. Small thin hemispherical porcelain capsules may be obtained from the dealers, about the size of the platinum dishes specified, which are more suitable than porcelain crucibles for the experiment. Such dishes may also be used in studying the effect of heat on organic substances, the char being burnt in the muffle furnace.

SCIENTIFIC SERIALS.

American Journal of Science, April.—On allotropic silver, by M. Carey Lea. This paper is in continuation of one contained in the March number of the *Journal*, in which the gold-coloured forms of allotropic silver were examined. The subject now considered is the relation existing between the allotropic forms of silver taken generally and silver as it exists in its compounds, and more especially in the silver haloids. The investigation leads to the conclusion that silver may exist in three forms:—(1) Allotropic silver, which is protean in its nature, may be soluble or insoluble in water, and have almost any colour; but in all its insoluble varieties always exhibits plasticity. It is chemically active. (2) The intermediate form, which may be yellow or green, but is never plastic, and is almost as indifferent chemically as white silver. (3) Ordinary silver. Allotropic silver is affected by all forms of energy, and the effects are strikingly analogous to those produced on silver haloids by the same agencies. It is, therefore, concluded that in the silver haloids silver may exist in the allotropic form.—The phenomena of rifting in granite, by Ralph S. Tarr.—The red-rock sandstone of Marion County, Iowa, by Charles R. Keyes.—The volumetric composition of water, by Edward W. Morley (continued from the March number of the *Journal*). The hydrogen used in the investigation was obtained by the electrolysis of dilute sulphuric acid. By this means it has been found possible to get hydrogen containing less than one-hundreth of a cubic centimetre of nitrogen in two litres of hydrogen, and containing no other impurity in amount large enough to be detected. An apparatus for the measurement of gases has been constructed, in which the mean error of measurement of the volume of hydrogen and oxygen used in the experiments has been less than one part in fifty thousand. With this, twenty experiments have been made, which give a maximum value for the composition of water 2·00047, a minimum value of 2·00005, and a mean value 2·00023. The composition of water may, therefore, be taken as 2·0002 volumes of hydrogen to one volume of oxygen.—On certain points in the estimation of barium as the sulphate, by F. W. Mar. Some experiments made by the author indicate that hydrochloric acid may be introduced freely and without detriment to quantitative exactness, in the precipitation of barium in the form of sulphate from pure solutions. Up to a determined point, the amount of hydrochloric acid employed accelerates the precipitation. The quantity of alkaline salts present is shown to have no very marked influence on the time of formation of the precipitate.—On halotrichite, or feather alum, from Pitkin County, Colorado, by E. H. S. Bailey. An analysis of the mineral shows that it is essentially a sulphate of alumina and ferrous oxide, with a part of the former replaced by ferric oxide, and a part of the ferrous oxide replaced by magnesia.—On a new serpent from Iowa, by R. Ellsworth Call.—On crystallized azurite from Arizona, by O. C. Farrington.—On the occurrence of xenotime as an accessory element in rocks, by Orville A. Derby.—On the magnetite ore districts of Jacupiranga and Ipanema, Sao Paulo, Brazil, by Orville A. Derby.—On pink grossularite from Mexico, by C. F. de Landero.—Restoration of *Triceratops*, by O. C. Marsh.—Development of the Brachiopods, Part 1, introduction, by Dr. Charles E. Beecher.

SOCIETIES AND ACADEMIES.

LONDON.

Geological Society, April 8.—Dr. W. T. Blanford, F.R.S., Vice-President, in the chair.—The following communications were read:—The Cross Fell inlier, by Prof. H. A. Nicholson and J. E. Marr. The tract of Lower Palæozoic rocks lying between the Carboniferous rocks of the Cross Fell range and the new red sandstone of the Eden Valley is about sixteen miles in length, and little more than a mile in average breadth; the inlier extends in a general north-north-west and south-south-east direction, and the normal strike of the rocks is about north-west and south-east. The tract is divided along its entire length by a fault, which separates the Skiddaw slates (with the Ellergill beds of one of the authors, and the Millburn series of Mr. Goodchild) from higher beds on the west. A detailed classification of the Skiddaw slates is not attempted, but the authors describe the succession of the rocks in the faulted blocks of the western portion. Their classification is as follows:—

Coniston grits = Ludlow.
Coniston flags (lower portion) = Wenlock.
Stockdale shales = Llandovery-Tarannon.
Ashgill shales
Staurocephalus limestone
Dufton shales and Keisley limestone } = Bala.
Corona beds
Rhyolitic group